# FUEL CELL SYSTEM

**Publication number:** JP2002252011
**Publication date:** 2002-09-06
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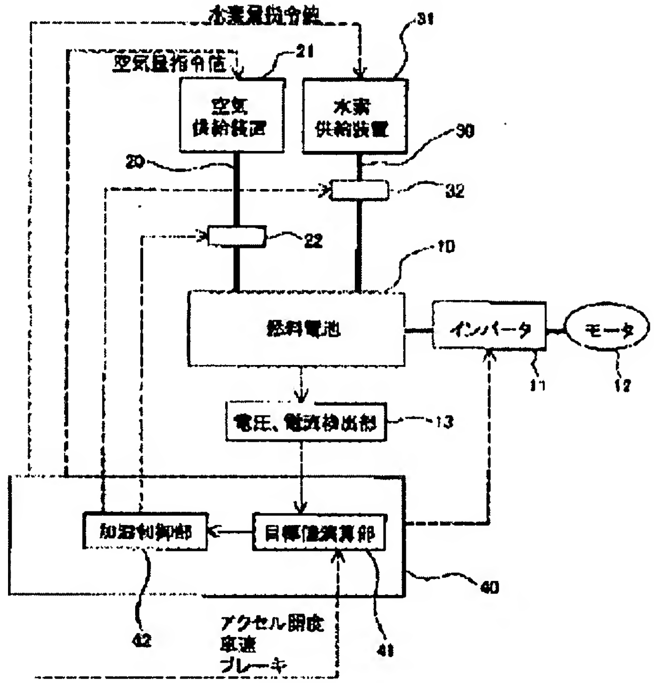
**Classification:**
- **international:** ***H01M8/10; H01M8/04;*** **H01M8/10; H01M8/04;** (IPC1-7): H01M8/04; H01M8/10
- **European:**

**Application number:** JP20010048712 20010223
**Priority number(s):** JP20010048712 20010223



Abstract of **JP2002252011**

PROBLEM TO BE SOLVED: To provide a fuel cell system which enables efficient power generation while keeping a moisture state inside the fuel cell optimal. SOLUTION: A moistening degree of oxygen supplied to the fuel cell 10 is controlled based on a demanded electric power amount Pr to the fuel cell 10 and an internal resistance Rp of the fuel cell 10 calculated from an output voltage value and output current value which have been detected with a voltage current detection means 13. When a ratio of the internal resistance Rp to an internal resistance theoretical value Rr of the fuel cell 10 exceeds a predetermined value, since it can be presumed that moisture is insufficient, the moistening degree of the oxygen supplied to the fuel cell 10 is increased in the predetermined amount.



JAPANESE [JP,2002-252011,A]



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* NOTICES *



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## CLAIMS

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[Claim(s)]
[Claim 1] It is a fuel cell system equipped with the fuel cell (10) which carries out electrochemical reaction of hydrogen and the oxygen, and generates electrical energy. A humidification means to humidify oxygen at least among the hydrogen supplied to said fuel cell (10), and oxygen (22 24), An electrical-potential-difference current detection means to detect the output voltage value and output current value of said fuel cell (10) (13), It is based on the internal resistance value (Rp) of said fuel cell (10) calculated from the demand electric energy (Pr) over said fuel cell (10), said output voltage value detected with said electrical-potential-difference current detection means (13), and said output current value. The fuel cell system characterized by having the control section (40) which controls whenever [ humidification / of the oxygen supplied to said fuel cell (10) ].
[Claim 2] Said control section (40) is what performs the amount control of humidification so that whenever [ humidification / of the oxygen supplied to said fuel cell (10) ] may turn into whenever [ target humidification ]. The fuel cell system according to claim 1 characterized by carrying out the increment in a predetermined value of whenever [ said target humidification ] when the ratio of said internal resistance value (Rp) to the internal resistance theoretical value (Rr) of said fuel cell (10) in said demand electric energy (Pr) is over the predetermined value.
[Claim 3] Said control section (40) is a fuel cell system according to claim 2 characterized by carrying out the increment in a predetermined value of whenever [ said target humidification ] when the variation (deltaPr) of said demand electric energy (Pr) is over predetermined variation.
[Claim 4] Said control section (40) is claim 1 characterized by setting up the initial value of whenever [ said target humidification ] highly as compared with the case where said current density is not over predetermined current density when the current density of said fuel cell (10) needed since said fuel cell (10) outputs said demand electric energy (Pr) is over predetermined current density thru/or the fuel cell system of any one publication of three.
[Claim 5] Said humidification means is bubbling-type humidification equipment (22) which makes the water stored in the tank pass gas. Said humidification equipment (22) is equipped with the bypass path (20a) for which the oxygen supplied to said fuel cell (10) can bypass said humidification equipment. Said control section (40)

Claim 1 characterized by for said oxygen controlling the rate of the time amount which passes said humidification equipment (22), and the time amount which passes said bypass path (20a), and controlling whenever [ humidification / of said oxygen ] thru/or the fuel cell system of any one publication of four.

[Claim 6] They are claim 1 which said humidification means is injector-type humidification equipment (24) which injects water into the oxygen supplied to said fuel cell (10), and is characterized by for said control section (40) controlling the moisture injection quantity of said humidification equipment (24), and controlling whenever [ humidification / of said oxygen ] thru/or the fuel cell system of any one publication of four.

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[Translation done.]

## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention applies [ to mobiles, such as a car, a vessel, and a portable electric organ, ] about the fuel cell system which consists of a fuel cell which generates electrical energy by the chemical reaction of hydrogen and oxygen and is effective.
[0002]
[Description of the Prior Art] For example, in the fuel cell system carried in an electric vehicle, the amount of hydrogen and the amount of oxygen (air content) for generating the power which a fuel cell needs for car transit are drawn, and these gas is supplied to the fuel cell.
[0003] It is known that the internal resistance of the fuel cell at the time of a generation of electrical energy will influence the wettability of the electrolyte membrane inside a fuel cell, when sufficient humidity is not acquired but an electrolyte membrane dries, internal resistance becomes large and the power loss in a fuel cell increases. For this reason, in order to perform an efficient electric power supply, it is necessary to supply, where hydrogen and air are humidified and to maintain the humidity inside a fuel cell.
[0004]
[Problem(s) to be Solved by the Invention] However, in the present condition, control of the amount of humidification to the hydrogen and air which are supplied to a fuel cell is not performed. For this reason, lack or the case where it becomes superfluous has the moisture inside a fuel cell to the load which changes with time.

[0005] Drawing 12 shows the relation of the load to a fuel cell, a cel electrical potential difference, average current density, and the humidity of the air supplied, and when a load increases rapidly, if the moisture contents inside a fuel cell run short, the output of a fuel cell will decline. Thus, when moisture runs short, there is a problem that internal resistance increases and the output and generating efficiency of a fuel cell fall.
[0006] Moreover, there is a problem that the output of a fuel cell declines, without the water condensed in the interior of a fuel cell closing a gas passageway, and the gas for a generation of electrical energy spreading enough, or a generation of electrical energy is impossible by the water condensed at the time of low

temperature being frozen, and starting becomes difficult when moisture is superfluous.
[0007] In view of the above-mentioned trouble, this invention keeps the moisture condition inside a fuel cell the optimal, and aims at offering the fuel cell system which enables an efficient generation of electrical energy.
[0008]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, in invention according to claim 1 It is a fuel cell system equipped with the fuel cell (10) which carries out electrochemical reaction of hydrogen and the oxygen, and generates electrical energy. A humidification means to humidify oxygen at least among the hydrogen supplied to a fuel cell (10), and oxygen (22 24), An electrical-potential-difference current detection means to detect the output voltage value and output current value of a fuel cell (10) (13), It is based on the internal resistance value (Rp) of the fuel cell (10) calculated from the demand electric energy (Pr) over a fuel cell (10), and the output voltage value and output current value detected with the electrical-potential-difference current detection means (13). It is characterized by having the control section (40) which controls whenever [ humidification / of the oxygen supplied to a fuel cell (10) ].
[0009] Thus, the wettability of the electrolyte membrane inside a fuel cell (10) can be maintained at an optimum state by controlling whenever [ humidification / of oxygen ] based on the demand electric energy (Pr) over a fuel cell (10), and the internal resistance value (Rp) of a fuel cell (10). In addition, "oxygen" includes the air not only containing an oxygen gas independent but oxygen gas in this specification.
[0010] Moreover, by invention according to claim 2, since it can presume that the moisture in a fuel cell is insufficient when the internal resistance value of a fuel cell (10) is large, when the ratio of an internal resistance value (Rp) to the internal resistance theoretical value (Rr) of the fuel cell (10) in demand electric energy (Pr) is over the predetermined value, the increment in a predetermined value of whenever [ target humidification ] is carried out.
[0011] Moreover, by invention according to claim 3, since the moisture in a fuel cell runs short when the load effect of a fuel cell is large (i.e., when fluctuation of the demand electric energy over a fuel cell is large), when the variation (deltaPr) of demand electric energy (Pr) is over predetermined variation, the increment in a predetermined value of whenever [ target humidification / of oxygen ] is carried out.
[0012] Moreover, in invention according to claim 4, the control section (40) is characterized by setting up the initial value of whenever [ target humidification ] highly as compared with the case where current density is not over predetermined current density, when the current density of the fuel cell (10) needed since a fuel cell (10) outputs demand electric energy (Pr) is over predetermined current density.
[0013] Thus, whenever [ air target humidification ] can be made into a quicker suitable value by setting up the initial value of whenever [ air target humidification ] low at the time of low loading, and setting it up highly at the time of a heavy load. In addition, it may replace with the current density of a fuel cell

(10), and the initial value of whenever [ target humidification ] may be set up based on the demand electric energy over a fuel cell.
[0014] Moreover, a humidification means can use the bubbling-type humidification equipment (22) which passes gas for the water stored in the tank like invention according to claim 5, or can use the injector-type humidification equipment (24) which injects water for the oxygen supplied to a fuel cell (10) like invention according to claim 6.
[0015] In addition, the sign in the parenthesis of each above-mentioned means shows correspondence relation with the concrete means of a publication to the operation gestalt mentioned later.
[0016]
[Embodiment of the Invention] (The 1st operation gestalt) The 1st operation gestalt of this invention is hereafter explained based on drawing 1 - drawing 8 . A **** 1 operation gestalt applies a fuel cell system to the electric vehicle (fuel cell car) which runs a fuel cell as a power source.
[0017] Drawing 1 shows the whole fuel cell system configuration of an operation gestalt. As shown in drawing 1 , the fuel cell system of this operation gestalt is equipped with the fuel cell (FC stack) 10 which generates power using the electrochemical reaction of hydrogen and oxygen. The solid-state polyelectrolyte mold fuel cell is used as a FC stack 10, two or more laminatings of the cel used as a base unit are carried out, and it consists of **** 1 operation gestalten. Each cel has the composition that the electrolyte membrane was inserted with the electrode of a pair.
[0018] In the FC stack 10, the electrochemical reaction of the following hydrogen and oxygen occurs and electrical energy occurs.
(Negative-electrode side) The H2 ->2H++2e-(positive-electrode side) 2H++1/2O2+2e-->H2OFC stack 10 is constituted so that power may be supplied to electrical machinery and apparatus, such as an inverter 11 and a rechargeable battery which is not illustrated. An inverter 11 changes into alternating current the direct current supplied from the FC stack 10, supplies it to a drive motor (load) 12, and is driving the motor 12. Drawing 2 is the enlarged drawing of the electrical-potential-difference current detecting element of the FC stack 10 in a fuel cell system, and as shown in drawing 2 , the electrical-potential-difference current detecting element 13 which detects the output voltage value and output current value of the FC stack 10 is formed in the FC stack 10.
[0019] Drawing 3 is the enlarged drawing of the gas supply section in a fuel cell system. As shown in drawing 3 , the air path 20 for supplying air (oxygen) to the oxygen pole (positive electrode) side of the FC stack 10 and the hydrogen path 30 for supplying hydrogen to the hydrogen pole (negative electrode) side of the FC stack 10 are formed in the fuel cell system. Air supply equipment 21 is formed in the air path 20, and the hydrogen feeder 31 is formed in the hydrogen path 30. As air supply equipment 21, the blower for air feeding (gas-compression machine) can be used, for example, and steam-reforming equipment can be used as a hydrogen feeder 31, for example.
[0020] It is necessary to make the electrolyte membrane in the FC stack 10 into the damp or wet condition containing moisture for the electrochemical reaction at

the time of a generation of electrical energy. For this reason, the humidification equipment 22 for humidifying to air is formed in the air path 20. Similarly, the humidification equipment 32 for humidifying in hydrogen is formed in the hydrogen path 30. As shown in drawing 3 , with the **** 1 operation gestalt, the humidification equipment of the bubbling method which the water in a tank is made to pass gas and is humidified in it is used for the humidification equipments 22 and 32.

[0021] Humidification is performed in the hydrogen which passes the air and the hydrogen path 30 of passing the air path 20, with these humidification equipments 22 and 32, and the air and hydrogen which were humidified are supplied to the FC stack 10. By this, the FC stack 10 interior will operate by the damp or wet condition.

[0022] In the fuel cell system of a **** 1 operation gestalt, as shown in drawing 3 , the bypass paths 20a and 30a of the humidification equipments 22 and 32 are formed in the air path 20 and the hydrogen path 30, respectively. The passage selector valves 23 and 33 are formed in the branch point of each gas paths 20 and 30 and bypass paths 20a and 30a. the passage selector valves 23 and 33 -- it is constituted so that gas may be passed to humidification equipment 21 and 31 side and gas may be passed to the bypass path 20a and 30a side in a sink and bulb-off by bulb-on.

[0023] Here, the amount control of humidification to the air or hydrogen by the humidification equipments 22 and 32 is explained. The amount control of humidification of the gas supplied to the FC stack 10 carries out duty ratio control of the passage selector valves 23 and 33, and is performed because gas controls the time amount rate of passing through the humidification equipments 22 and 32 and the bypass paths 20a and 30a.

[0024] Drawing 4 is the control explanatory view of the humidification equipments 22 and 32. Drawing 4 (a) is the map which set up beforehand the relation between Hr (%RH: relative humidity) and the bulb-on duty Dt (%) whenever [ target humidification ], and drawing 4 (b) shows the relation between the valve-action period Tp (second) and the bulb-on time amount Ton (second). The bulb-on duty Dt is the rate of the bulb-on time amount Ton in the valve-action period Tp. The map of drawing 4 (a) is suitably set up according to the class of humidification equipments 22 and 32 etc. The valve-action period Tp can be set as arbitration, and is made into Tp= 5 seconds with this operation gestalt.

[0025] Based on whenever [ target humidification ], the bulb-on duty Dt is searched for from the map of drawing 4 (a), and the bulb-on time amount Ton over the valve-action period Tp is found by Ton=TpxDt/100 (second).

[0026] Drawing 5 shows the migration condition of the moisture in the FC stack 10 interior. As shown in drawing 5 , in the FC stack 10 interior, the moisture by the side of air pole 10c diffuses the inside of electrolyte membrane 10b in the hydrogen pole 10a side from the air pole 10c side. The conductivity of electrolyte membrane 10b will be kept to some extent large by this moisture diffusion.

[0027] Drawing 6 shows the relation of hydrogen humidity (%RH) in case air humidity is 100%RH, current density (A/cm2), and single cell voltage (V). Drawing 6 shows that the relation between current density and a cel electrical potential

difference hardly receives effect in change of hydrogen humidity.
[0028] Therefore, by the fuel cell system of a **** 1 operation gestalt, the amount of humidification of hydrogen is reduced as much as possible, and humidity control of the FC stack 10 interior is performed by mainly controlling the amount of humidification of air.
[0029] The control section (ECU) 40 which performs various control is formed in the fuel cell system of this operation gestalt. The control section 40 is equipped with the desired value operation part 41 which calculates whenever [ target humidification / of gas ], and the amount control section 42 of humidification which controls the amount of gas humidification based on whenever [ target humidification ]. An electrical-potential-difference value, a current value, etc. from a demand power signal and the electrical-potential-difference current detecting element 13 from a load 11 are inputted into a control section 40. Moreover, the control section 50 is constituted so that a control signal may be outputted to an inverter 11, gas transfer units 21 and 31, the passage selector valve 23, and 33 grades.
[0030] Next, actuation of the fuel cell system of the above-mentioned configuration is explained based on drawing 7 . Drawing 7 is a flow chart which shows actuation of the fuel cell system of this operation gestalt. In addition, let control periods be several mm second - dozens mses.
[0031] First, the target humidity Hh of hydrogen is set up (step S10), and the target humidity basic value Hbo of air is set up (step S11). The hydrogen target humidity Hh is set for example, as RH 20%, and the air target humidity basic value Hbo is set for example, as RH 30%. The initial value of the air target humidity correction value Hfbo is set as 0 (step S12).
[0032] Next, based on signals, such as accelerator opening, the vehicle speed, and a brake, the demand power Pr needed for car transit is detected (step S13). Difference deltaPr with the demand power Pr at the time of control (t-1) is computed the current demand power Pr (t) and last time (step S14), and it judges whether variation deltaPr of demand power is over the predetermined value alpha (for example, 5kW) (step S15). That is, it judges whether the load effect to the FC stack 10 is rapid increase.
[0033] Consequently, when variation deltaPr of demand power is over the predetermined value alpha, first, the electrical-potential-difference current detecting element 13 detects the current output voltage value **** and the current output current value Ip of the FC stack 10 (step S16), and the current internal resistance value Rp of the FC stack 10 is computed by Rp=****/Ip (step S17).
[0034] Next, the internal resistance reference value Rr of the FC stack 10 in the demand power Pr detected at the above-mentioned step S13 is calculated (step S18). Drawing 8 is the map which set up beforehand the relation between the demand power Pr and the internal resistance value Rr of the FC stack 10. From the map shown in drawing 8 , the internal resistance reference value Rr when the FC stack 10 outputs the demand power Pr is calculated.
[0035] Next, it judges whether the ratio to the internal resistance reference value Rr in the demand power Pr of the current internal resistance value Rp is over the

predetermined value beta (for example, 110%), and whether it is Rp/Rr>=beta (step S19). That is, it judges whether the actual internal resistance value Rp is too large to the internal resistance reference value Rr which is an internal resistance theoretical value to the demand electric energy Pr.
[0036] Consequently, since it is presumed that the actual internal resistance value Rp runs short of the moisture contents in the FC stack 10 beyond the predetermined value to the internal resistance reference value Rr in being large, only the predetermined value gamma (for example, 1%RH) makes the air target humidity correction value Hfbo increase (step S20).
[0037] On the other hand, since it is presumed to the internal resistance reference value Rr that the moisture contents in the FC stack 10 are insufficient when the current internal resistance value Rp is smaller than a predetermined value, only the predetermined value gamma decreases the air target humidity correction value Hfbo (step S21). Moreover, also when variation deltaPr of demand power is not over the predetermined value alpha at the above-mentioned step S15, only the predetermined value gamma decreases the air target humidity correction value Hfbo similarly. It can prevent that the amount of air humidification to which it is made to increase at step S20 increases to infinity by this.
[0038] Next, it asks for the final air target humidity Ho from the sum of the air target humidity basic value Hbo and the air target humidity correction value Hfbo (step S22). A bound value is set as this air target humidity Ho (step S23). That is, when the air target humidity Ho is smaller than 0%RH, it is set as RH 0%, and in being larger than 100%RH, it sets it as RH 100%.
[0039] Next, based on the air target humidity Ho and the hydrogen target humidity Hh, the humidification equipments 22 and 32 perform humidification control of air or hydrogen (step S24). As mentioned above, humidification control is performed by the duty ratio control using the passage selector valves 23 and 33 so that whenever [ humidification / of the air and hydrogen which are supplied to the FC stack 10 ] may turn into the air target humidity Ho and the hydrogen target humidity Hh. Hereafter, it carries out by repeating the control loop of the above-mentioned steps S13-S24.
[0040] As mentioned above, an internal resistance value is presumed according to the condition of a load, and it becomes possible by controlling the amount of humidification of gas based on this internal resistance value to always make the optimal the moisture condition of the FC stack 10 interior. Thereby, an efficient generation of electrical energy is attained. Moreover, since the moisture content inside a fuel cell can be lessened, the starting nature of the fuel cell at the time of low temperature can also be raised.
[0041] In addition, the hydrogen target humidity Hh, the air target humidity basic value Hbo, and the predetermined values alpha, beta, and gamma are values which can be set as arbitration according to the class of fuel cell etc.
[0042] (The 2nd operation gestalt) Next, the 2nd operation gestalt of this invention is explained based on drawing 9 . It differs in that the humidification equipment 32 with which the **** 2 operation gestalt was prepared in the hydrogen path 30 as compared with the above-mentioned 1st operation gestalt was omitted. The same part as the above-mentioned 1st operation gestalt attaches the same sign, and

omits explanation.
[0043] Drawing 9 shows the whole fuel cell system configuration of a **** 2 operation gestalt. As the above-mentioned 1st operation gestalt explained based on drawing 5 and drawing 6 , the output of a fuel cell hardly receives effect in the humidity of supply hydrogen. For this reason, as shown in drawing 9 , in the fuel cell system of a **** 2 operation gestalt, humidification equipment is not formed in the hydrogen path 30, but humidification equipment 22 is formed only in the air path 20, and humidity control of the FC stack 10 interior is performed by controlling the amount of humidification of a supply air.
[0044] In the FC stack 10 interior, since the moisture by the side of an air pole diffuses the inside of an electrolyte membrane in a hydrogen pole side, the conductivity of an electrolyte membrane is kept to some extent large by such configuration. Therefore, the same effectiveness as the fuel cell system of the above-mentioned 1st operation gestalt can be acquired also by the configuration of a **** 2 operation gestalt. Moreover, according to the configuration of a **** 2 operation gestalt, simplification of a system can be attained.
[0045] (The 3rd operation gestalt) Next, the 3rd operation gestalt of this invention is explained based on drawing 10 . As compared with the above-mentioned 1st operation gestalt, as for a **** 3 operation gestalt, the setting approaches of the air target humidity basic value Hbo differ. The same part as the above-mentioned 1st operation gestalt attaches the same sign, and omits explanation.
[0046] Drawing 10 is a flow chart which shows the configuration procedure of the air target humidity basic value Hbo, and supports step S11 of drawing 7 explained with the above-mentioned 1st operation gestalt. Hereafter, based on drawing 10 , the setting approach of the air target humidity basic value Hbo in a **** 3 operation gestalt is explained.
[0047] First, based on signals, such as accelerator opening, accelerator opening, the vehicle speed, and a brake, the demand electric energy Pr needed for car transit is detected (step S110). Next, the current density Ir required since the FC stack 10 outputs the demand electric energy Pr is computed (step S111). The need [ of receiving the demand electric energy Pr ] current density Ir becomes settled uniquely according to the class of inverter 11.
[0048] Next, it judges whether the load to whether the need current density Ir is over predetermined current density and the FC stack 10 is a heavy load, or it is low loading (step S112). The predetermined current density which is the reference value of whether it is a heavy load or to be low loading is the value which can be set as arbitration according to the class of fuel cell etc., for example, as shown in drawing 12 , it can be set up with 0.3 A/cm2.
[0049] Consequently, when the need current density Ir is over the predetermined value, the air target humidity basic value Hbo is set for example, as RH 80 to 100% (step S113). On the other hand, when the need current density Ir is not over the predetermined value, the air target humidity basic value Hbo is set for example, as RH 20 to 30% (step S114). It is the value which can also set these values as arbitration according to the class of fuel cell etc.
[0050] Thus, Ho can be made into a quicker suitable value whenever [ air target humidification ] by setting up the initial value of the air target humidity Ho low at

the time of low loading, and setting it up highly at the time of a heavy load.
[0051] (The 4th operation gestalt) Next, the 4th operation gestalt of this invention is explained based on drawing 11 . As for a **** 4 operation gestalt, the configurations of the humidification equipments 22 and 32 differ as compared with the above-mentioned 1st operation gestalt. The same part as the above-mentioned 1st operation gestalt attaches the same sign, and omits explanation.
[0052] Drawing 11 is the schematic diagram of the fuel cell system of a **** 4 operation gestalt. The same part as the above-mentioned 1st operation gestalt is omitting illustration suitably.
[0053] As shown in drawing 11 , with the **** 4 operation gestalt, the injector-type gas humidification equipments 24 and 34 are formed. Pure water is supplied from the pure tank 14, and the injector type humidification equipments 24 and 34 inject water in a gas passageway 20 and 30 based on the control signal from a control section 40, and they are constituted so that it may humidify in gas. Based on the air target humidity Ho and the hydrogen target humidity Hh, the moisture injection quantity is controlled by the injector type humidification equipments 24 and 34.
[0054] Responsibility becomes possible [ performing highly precise humidification control ] well more by using such injector type humidification equipments 24 and 34.
[0055] (Other operation gestalten) although controlled in addition by establishing the bypass paths 20a and 30a in the bubbling type humidification equipments 22 and 32, and carrying out duty ratio control whenever [ humidification ] with the above 1st - the 3rd operation gestalt -- not only this -- for example, humidity control can be performed also by adjusting the temperature of the humidified gas. By raising gas temperature, humidity can be made low and, specifically, humidity can be made high by lowering gas temperature.

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[Translation done.]

* NOTICES *



## TECHNICAL FIELD

[Field of the Invention] This invention applies [ to mobiles, such as a car, a vessel, and a portable electric organ, ] about the fuel cell system which consists of a fuel cell which generates electrical energy by the chemical reaction of hydrogen and oxygen and is effective.

[Translation done.]

## PRIOR ART

[Description of the Prior Art] For example, in the fuel cell system carried in an electric vehicle, the amount of hydrogen and the amount of oxygen (air content) for generating the power which a fuel cell needs for car transit are drawn, and these gas is supplied to the fuel cell.
[0003] It is known that the internal resistance of the fuel cell at the time of a generation of electrical energy will influence the wettability of the electrolyte membrane inside a fuel cell, when sufficient humidity is not acquired but an electrolyte membrane dries, internal resistance becomes large and the power loss in a fuel cell increases. For this reason, in order to perform an efficient electric power supply, it is necessary to supply, where hydrogen and air are humidified and to maintain the humidity inside a fuel cell.

[Translation done.]

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## TECHNICAL PROBLEM

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[Problem(s) to be Solved by the Invention] However, in the present condition, control of the amount of humidification to the hydrogen and air which are supplied to a fuel cell is not performed. For this reason, lack or the case where it becomes superfluous has the moisture inside a fuel cell to the load which changes with time.

[0005] Drawing 12 shows the relation of the load to a fuel cell, a cel electrical potential difference, average current density, and the humidity of the air supplied, and when a load increases rapidly, if the moisture contents inside a fuel cell run short, the output of a fuel cell will decline. Thus, when moisture runs short, there is a problem that internal resistance increases and the output and generating efficiency of a fuel cell fall.
[0006] Moreover, there is a problem that the output of a fuel cell declines, without the water condensed in the interior of a fuel cell closing a gas passageway, and the gas for a generation of electrical energy spreading enough, or a generation of electrical energy is impossible by the water condensed at the time of low temperature being frozen, and starting becomes difficult when moisture is superfluous.
[0007] In view of the above-mentioned trouble, this invention keeps the moisture condition inside a fuel cell the optimal, and aims at offering the fuel cell system which enables an efficient generation of electrical energy.

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[Translation done.]

## MEANS

[Means for Solving the Problem] In order to attain the above-mentioned purpose, in invention according to claim 1 It is a fuel cell system equipped with the fuel cell (10) which carries out electrochemical reaction of hydrogen and the oxygen, and generates electrical energy. A humidification means to humidify oxygen at least among the hydrogen supplied to a fuel cell (10), and oxygen (22 24), An electrical-potential-difference current detection means to detect the output voltage value and output current value of a fuel cell (10) (13), It is based on the internal resistance value (Rp) of the fuel cell (10) calculated from the demand electric energy (Pr) over a fuel cell (10), and the output voltage value and output current value detected with the electrical-potential-difference current detection means (13). It is characterized by having the control section (40) which controls whenever [ humidification / of the oxygen supplied to a fuel cell (10) ].
[0009] Thus, the wettability of the electrolyte membrane inside a fuel cell (10) can be maintained at an optimum state by controlling whenever [ humidification / of oxygen ] based on the demand electric energy (Pr) over a fuel cell (10), and the internal resistance value (Rp) of a fuel cell (10). In addition, "oxygen" includes the air not only containing an oxygen gas independent but oxygen gas in this specification.
[0010] Moreover, by invention according to claim 2, since it can presume that the moisture in a fuel cell is insufficient when the internal resistance value of a fuel cell (10) is large, when the ratio of an internal resistance value (Rp) to the internal resistance theoretical value (Rr) of the fuel cell (10) in demand electric energy (Pr) is over the predetermined value, the increment in a predetermined value of whenever [ target humidification ] is carried out.
[0011] Moreover, by invention according to claim 3, since the moisture in a fuel cell runs short when the load effect of a fuel cell is large (i.e., when fluctuation of the demand electric energy over a fuel cell is large), when the variation (deltaPr) of demand electric energy (Pr) is over predetermined variation, the increment in a predetermined value of whenever [ target humidification / of oxygen ] is carried out.
[0012] Moreover, in invention according to claim 4, the control section (40) is characterized by setting up the initial value of whenever [ target humidification ] highly as compared with the case where current density is not over predetermined current density, when the current density of the fuel cell (10) needed since a fuel

cell (10) outputs demand electric energy (Pr) is over predetermined current density.

[0013] Thus, whenever [ air target humidification ] can be made into a quicker suitable value by setting up the initial value of whenever [ air target humidification ] low at the time of low loading, and setting it up highly at the time of a heavy load. In addition, it may replace with the current density of a fuel cell (10), and the initial value of whenever [ target humidification ] may be set up based on the demand electric energy over a fuel cell.

[0014] Moreover, a humidification means can use the bubbling-type humidification equipment (22) which passes gas for the water stored in the tank like invention according to claim 5, or can use the injector-type humidification equipment (24) which injects water for the oxygen supplied to a fuel cell (10) like invention according to claim 6.

[0015] In addition, the sign in the parenthesis of each above-mentioned means shows correspondence relation with the concrete means of a publication to the operation gestalt mentioned later.

[0016]

[Embodiment of the Invention] (The 1st operation gestalt) The 1st operation gestalt of this invention is hereafter explained based on drawing 1 - drawing 8 . A **** 1 operation gestalt applies a fuel cell system to the electric vehicle (fuel cell car) which runs a fuel cell as a power source.

[0017] Drawing 1 shows the whole fuel cell system configuration of an operation gestalt. As shown in drawing 1 , the fuel cell system of this operation gestalt is equipped with the fuel cell (FC stack) 10 which generates power using the electrochemical reaction of hydrogen and oxygen. The solid-state polyelectrolyte mold fuel cell is used as a FC stack 10, two or more laminatings of the cel used as a base unit are carried out, and it consists of **** 1 operation gestalten. Each cel has the composition that the electrolyte membrane was inserted with the electrode of a pair.

[0018] In the FC stack 10, the electrochemical reaction of the following hydrogen and oxygen occurs and electrical energy occurs.

(Negative-electrode side) The H2 ->2H++2e-(positive-electrode side) 2H++1/2O2+2e-->H2OFC stack 10 is constituted so that power may be supplied to electrical machinery and apparatus, such as an inverter 11 and a rechargeable battery which is not illustrated. An inverter 11 changes into alternating current the direct current supplied from the FC stack 10, supplies it to a drive motor (load) 12, and is driving the motor 12. Drawing 2 is the enlarged drawing of the electrical-potential-difference current detecting element of the FC stack 10 in a fuel cell system, and as shown in drawing 2 , the electrical-potential-difference current detecting element 13 which detects the output voltage value and output current value of the FC stack 10 is formed in the FC stack 10.

[0019] Drawing 3 is the enlarged drawing of the gas supply section in a fuel cell system. As shown in drawing 3 , the air path 20 for supplying air (oxygen) to the oxygen pole (positive electrode) side of the FC stack 10 and the hydrogen path 30 for supplying hydrogen to the hydrogen pole (negative electrode) side of the FC stack 10 are formed in the fuel cell system. Air supply equipment 21 is formed in

the air path 20, and the hydrogen feeder 31 is formed in the hydrogen path 30. As air supply equipment 21, the blower for air feeding (gas-compression machine) can be used, for example, and steam-reforming equipment can be used as a hydrogen feeder 31, for example.
[0020] It is necessary to make the electrolyte membrane in the FC stack 10 into the damp or wet condition containing moisture for the electrochemical reaction at the time of a generation of electrical energy. For this reason, the humidification equipment 22 for humidifying to air is formed in the air path 20. Similarly, the humidification equipment 32 for humidifying in hydrogen is formed in the hydrogen path 30. As shown in drawing 3 , with the **** 1 operation gestalt, the humidification equipment of the bubbling method which the water in a tank is made to pass gas and is humidified in it is used for the humidification equipments 22 and 32.
[0021] Humidification is performed in the hydrogen which passes the air and the hydrogen path 30 of passing the air path 20, with these humidification equipments 22 and 32, and the air and hydrogen which were humidified are supplied to the FC stack 10. By this, the FC stack 10 interior will operate by the damp or wet condition.
[0022] In the fuel cell system of a **** 1 operation gestalt, as shown in drawing 3 , the bypass paths 20a and 30a of the humidification equipments 22 and 32 are formed in the air path 20 and the hydrogen path 30, respectively. The passage selector valves 23 and 33 are formed in the branch point of each gas paths 20 and 30 and bypass paths 20a and 30a. the passage selector valves 23 and 33 -- it is constituted so that gas may be passed to humidification equipment 21 and 31 side and gas may be passed to the bypass path 20a and 30a side in a sink and bulb-off by bulb-on.
[0023] Here, the amount control of humidification to the air or hydrogen by the humidification equipments 22 and 32 is explained. The amount control of humidification of the gas supplied to the FC stack 10 carries out duty ratio control of the passage selector valves 23 and 33, and is performed because gas controls the time amount rate of passing through the humidification equipments 22 and 32 and the bypass paths 20a and 30a.
[0024] Drawing 4 is the control explanatory view of the humidification equipments 22 and 32. Drawing 4 (a) is the map which set up beforehand the relation between Hr (%RH: relative humidity) and the bulb-on duty Dt (%) whenever [ target humidification ], and drawing 4 (b) shows the relation between the valve-action period Tp (second) and the bulb-on time amount Ton (second). The bulb-on duty Dt is the rate of the bulb-on time amount Ton in the valve-action period Tp. The map of drawing 4 (a) is suitably set up according to the class of humidification equipments 22 and 32 etc. The valve-action period Tp can be set as arbitration, and is made into Tp= 5 seconds with this operation gestalt.
[0025] Based on whenever [ target humidification ], the bulb-on duty Dt is searched for from the map of drawing 4 (a), and the bulb-on time amount Ton over the valve-action period Tp is found by Ton=TpxDt/100 (second).
[0026] Drawing 5 shows the migration condition of the moisture in the FC stack 10 interior. As shown in drawing 5 , in the FC stack 10 interior, the moisture by the

side of air pole 10c diffuses the inside of electrolyte membrane 10b in the hydrogen pole 10a side from the air pole 10c side. The conductivity of electrolyte membrane 10b will be kept to some extent large by this moisture diffusion.
[0027] Drawing 6 shows the relation of hydrogen humidity (%RH) in case air humidity is 100%RH, current density (A/cm2), and single cell voltage (V). Drawing 6 shows that the relation between current density and a cel electrical potential difference hardly receives effect in change of hydrogen humidity.
[0028] Therefore, by the fuel cell system of a **** 1 operation gestalt, the amount of humidification of hydrogen is reduced as much as possible, and humidity control of the FC stack 10 interior is performed by mainly controlling the amount of humidification of air.
[0029] The control section (ECU) 40 which performs various control is formed in the fuel cell system of this operation gestalt. The control section 40 is equipped with the desired value operation part 41 which calculates whenever [ target humidification / of gas ], and the amount control section 42 of humidification which controls the amount of gas humidification based on whenever [ target humidification ]. An electrical-potential-difference value, a current value, etc. from a demand power signal and the electrical-potential-difference current detecting element 13 from a load 11 are inputted into a control section 40. Moreover, the control section 50 is constituted so that a control signal may be outputted to an inverter 11, gas transfer units 21 and 31, the passage selector valve 23, and 33 grades.
[0030] Next, actuation of the fuel cell system of the above-mentioned configuration is explained based on drawing 7 . Drawing 7 is a flow chart which shows actuation of the fuel cell system of this operation gestalt. In addition, let control periods be several mm second - dozens mses.
[0031] First, the target humidity Hh of hydrogen is set up (step S10), and the target humidity basic value Hbo of air is set up (step S11). The hydrogen target humidity Hh is set for example, as RH 20%, and the air target humidity basic value Hbo is set for example, as RH 30%. The initial value of the air target humidity correction value Hfbo is set as 0 (step S12).
[0032] Next, based on signals, such as accelerator opening, the vehicle speed, and a brake, the demand power Pr needed for car transit is detected (step S13). Difference deltaPr with the demand power Pr at the time of control (t-1) is computed the current demand power Pr (t) and last time (step S14), and it judges whether variation deltaPr of demand power is over the predetermined value alpha (for example, 5kW) (step S15). That is, it judges whether the load effect to the FC stack 10 is rapid increase.
[0033] Consequently, when variation deltaPr of demand power is over the predetermined value alpha, first, the electrical-potential-difference current detecting element 13 detects the current output voltage value **** and the current output current value Ip of the FC stack 10 (step S16), and the current internal resistance value Rp of the FC stack 10 is computed by Rp=****/Ip (step S17).
[0034] Next, the internal resistance reference value Rr of the FC stack 10 in the demand power Pr detected at the above-mentioned step S13 is calculated (step

S18). Drawing 8 is the map which set up beforehand the relation between the demand power Pr and the internal resistance value Rr of the FC stack 10. From the map shown in drawing 8 , the internal resistance reference value Rr when the FC stack 10 outputs the demand power Pr is calculated.
[0035] Next, it judges whether the ratio to the internal resistance reference value Rr in the demand power Pr of the current internal resistance value Rp is over the predetermined value beta (for example, 110%), and whether it is Rp/Rr>=beta (step S19). That is, it judges whether the actual internal resistance value Rp is too large to the internal resistance reference value Rr which is an internal resistance theoretical value to the demand electric energy Pr.
[0036] Consequently, since it is presumed that the actual internal resistance value Rp runs short of the moisture contents in the FC stack 10 beyond the predetermined value to the internal resistance reference value Rr in being large, only the predetermined value gamma (for example, 1%RH) makes the air target humidity correction value Hfbo increase (step S20).
[0037] On the other hand, since it is presumed to the internal resistance reference value Rr that the moisture contents in the FC stack 10 are insufficient when the current internal resistance value Rp is smaller than a predetermined value, only the predetermined value gamma decreases the air target humidity correction value Hfbo (step S21). Moreover, also when variation deltaPr of demand power is not over the predetermined value alpha at the above-mentioned step S15, only the predetermined value gamma decreases the air target humidity correction value Hfbo similarly. It can prevent that the amount of air humidification to which it is made to increase at step S20 increases to infinity by this.
[0038] Next, it asks for the final air target humidity Ho from the sum of the air target humidity basic value Hbo and the air target humidity correction value Hfbo (step S22). A bound value is set as this air target humidity Ho (step S23). That is, when the air target humidity Ho is smaller than 0%RH, it is set as RH 0%, and in being larger than 100%RH, it sets it as RH 100%.
[0039] Next, based on the air target humidity Ho and the hydrogen target humidity Hh, the humidification equipments 22 and 32 perform humidification control of air or hydrogen (step S24). As mentioned above, humidification control is performed by the duty ratio control using the passage selector valves 23 and 33 so that whenever [ humidification / of the air and hydrogen which are supplied to the FC stack 10 ] may turn into the air target humidity Ho and the hydrogen target humidity Hh. Hereafter, it carries out by repeating the control loop of the above-mentioned steps S13-S24.
[0040] As mentioned above, an internal resistance value is presumed according to the condition of a load, and it becomes possible by controlling the amount of humidification of gas based on this internal resistance value to always make the optimal the moisture condition of the FC stack 10 interior. Thereby, an efficient generation of electrical energy is attained. Moreover, since the moisture content inside a fuel cell can be lessened, the starting nature of the fuel cell at the time of low temperature can also be raised.
[0041] In addition, the hydrogen target humidity Hh, the air target humidity basic value Hbo, and the predetermined values alpha, beta, and gamma are values which

can be set as arbitration according to the class of fuel cell etc.
[0042] (The 2nd operation gestalt) Next, the 2nd operation gestalt of this invention is explained based on drawing 9 . It differs in that the humidification equipment 32 with which the **** 2 operation gestalt was prepared in the hydrogen path 30 as compared with the above-mentioned 1st operation gestalt was omitted. The same part as the above-mentioned 1st operation gestalt attaches the same sign, and omits explanation.
[0043] Drawing 9 shows the whole fuel cell system configuration of a **** 2 operation gestalt. As the above-mentioned 1st operation gestalt explained based on drawing 5 and drawing 6 , the output of a fuel cell hardly receives effect in the humidity of supply hydrogen. For this reason, as shown in drawing 9 , in the fuel cell system of a **** 2 operation gestalt, humidification equipment is not formed in the hydrogen path 30, but humidification equipment 22 is formed only in the air path 20, and humidity control of the FC stack 10 interior is performed by controlling the amount of humidification of a supply air.
[0044] In the FC stack 10 interior, since the moisture by the side of an air pole diffuses the inside of an electrolyte membrane in a hydrogen pole side, the conductivity of an electrolyte membrane is kept to some extent large by such configuration. Therefore, the same effectiveness as the fuel cell system of the above-mentioned 1st operation gestalt can be acquired also by the configuration of a **** 2 operation gestalt. Moreover, according to the configuration of a **** 2 operation gestalt, simplification of a system can be attained.
[0045] (The 3rd operation gestalt) Next, the 3rd operation gestalt of this invention is explained based on drawing 10 . As compared with the above-mentioned 1st operation gestalt, as for a **** 3 operation gestalt, the setting approaches of the air target humidity basic value Hbo differ. The same part as the above-mentioned 1st operation gestalt attaches the same sign, and omits explanation.
[0046] Drawing 10 is a flow chart which shows the configuration procedure of the air target humidity basic value Hbo, and supports step S11 of drawing 7 explained with the above-mentioned 1st operation gestalt. Hereafter, based on drawing 10 , the setting approach of the air target humidity basic value Hbo in a **** 3 operation gestalt is explained.
[0047] First, based on signals, such as accelerator opening, accelerator opening, the vehicle speed, and a brake, the demand electric energy Pr needed for car transit is detected (step S110). Next, the current density Ir required since the FC stack 10 outputs the demand electric energy Pr is computed (step S111). The need [ of receiving the demand electric energy Pr ] current density Ir becomes settled uniquely according to the class of inverter 11.
[0048] Next, it judges whether the load to whether the need current density Ir is over predetermined current density and the FC stack 10 is a heavy load, or it is low loading (step S112). The predetermined current density which is the reference value of whether it is a heavy load or to be low loading is the value which can be set as arbitration according to the class of fuel cell etc., for example, as shown in drawing 12 , it can be set up with 0.3 A/cm2.
[0049] Consequently, when the need current density Ir is over the predetermined value, the air target humidity basic value Hbo is set for example, as RH 80 to 100%

(step S113). On the other hand, when the need current density Ir is not over the predetermined value, the air target humidity basic value Hbo is set for example, as RH 20 to 30% (step S114). It is the value which can also set these values as arbitration according to the class of fuel cell etc.
[0050] Thus, Ho can be made into a quicker suitable value whenever [ air target humidification ] by setting up the initial value of the air target humidity Ho low at the time of low loading, and setting it up highly at the time of a heavy load.
[0051] (The 4th operation gestalt) Next, the 4th operation gestalt of this invention is explained based on drawing 11 . As for a **** 4 operation gestalt, the configurations of the humidification equipments 22 and 32 differ as compared with the above-mentioned 1st operation gestalt. The same part as the above-mentioned 1st operation gestalt attaches the same sign, and omits explanation.
[0052] Drawing 11 is the schematic diagram of the fuel cell system of a **** 4 operation gestalt. The same part as the above-mentioned 1st operation gestalt is omitting illustration suitably.
[0053] As shown in drawing 11 , with the **** 4 operation gestalt, the injector-type gas humidification equipments 24 and 34 are formed. Pure water is supplied from the pure tank 14, and the injector type humidification equipments 24 and 34 inject water in a gas passageway 20 and 30 based on the control signal from a control section 40, and they are constituted so that it may humidify in gas. Based on the air target humidity Ho and the hydrogen target humidity Hh, the moisture injection quantity is controlled by the injector type humidification equipments 24 and 34.
[0054] Responsibility becomes possible [ performing highly precise humidification control ] well more by using such injector type humidification equipments 24 and 34.
[0055] (Other operation gestalten) although controlled in addition by establishing the bypass paths 20a and 30a in the bubbling type humidification equipments 22 and 32, and carrying out duty ratio control whenever [ humidification ] with the above 1st - the 3rd operation gestalt -- not only this -- for example, humidity control can be performed also by adjusting the temperature of the humidified gas. By raising gas temperature, humidity can be made low and, specifically, humidity can be made high by lowering gas temperature.

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[Translation done.]

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]
[Drawing 1] It is the conceptual diagram of the fuel cell system of the above-mentioned 1st operation gestalt.
[Drawing 2] It is the expansion conceptual diagram of the fuel cell of drawing 1 .
[Drawing 3] It is the expansion conceptual diagram of the humidification equipment of drawing 1 .
[Drawing 4] It is the property Fig. showing humidification control of a humidifier.
[Drawing 5] It is the conceptual diagram showing the migration condition of the moisture in the interior of a fuel cell.
[Drawing 6] It is the property Fig. showing the relation of hydrogen humidity, air humidity, a cel electrical potential difference, and current density.
[Drawing 7] It is the flow chart which shows humidification control of the fuel cell system of the above-mentioned 1st operation gestalt.
[Drawing 8] It is the property Fig. showing the relation between demand power and internal resistance.
[Drawing 9] It is the conceptual diagram of the fuel cell system of the above-mentioned 2nd operation gestalt.
[Drawing 10] It is the flow chart of the fuel cell system of the above-mentioned 3rd operation gestalt.
[Drawing 11] It is the conceptual diagram of the fuel cell system of the above-mentioned 4th operation gestalt.
[Drawing 12] It is the property Fig. showing the relation of the load to a fuel cell, a cel electrical potential difference, average current density, and the humidity of the air supplied.
[Description of Notations]
10 [ -- 22 A gas transfer unit, 32 / -- Humidification equipment, 40 / -- Control section. ] -- A fuel cell (FC stack), 13 -- 20 An electrical-potential-difference current detecting element, 30 -- 21 A gas path, 31

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[Translation done.]

* NOTICES *

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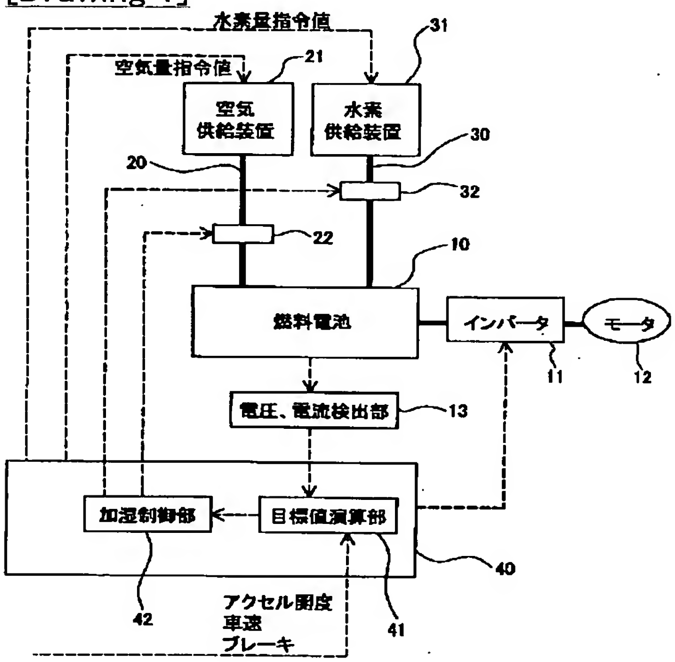
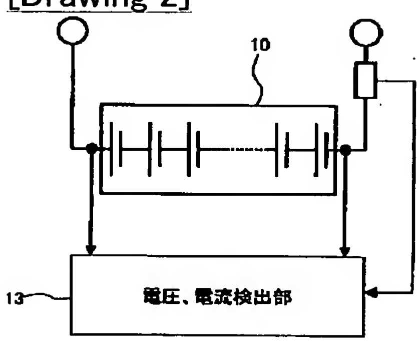
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

## DRAWINGS

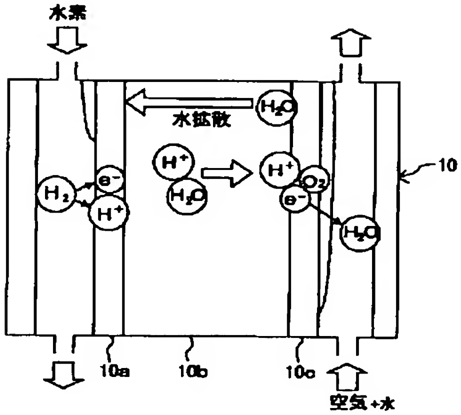
[Drawing 1]



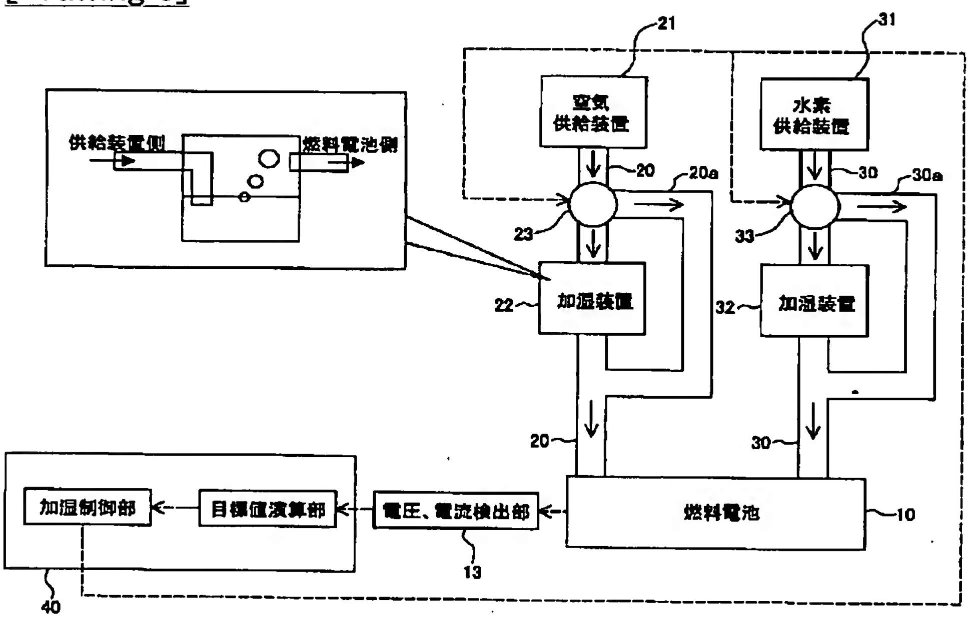

[Drawing 2]



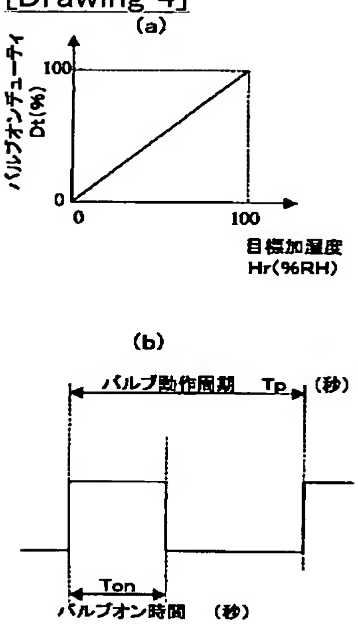

[Drawing 5]



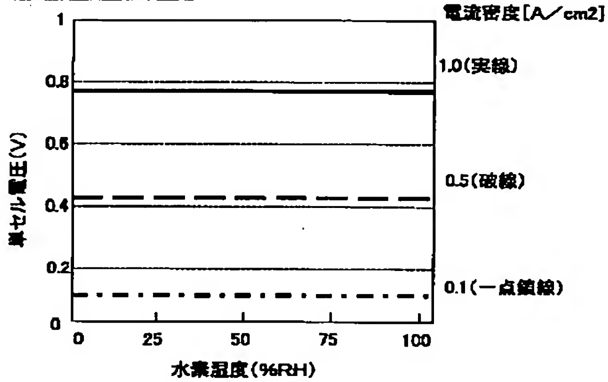

[Drawing 3]



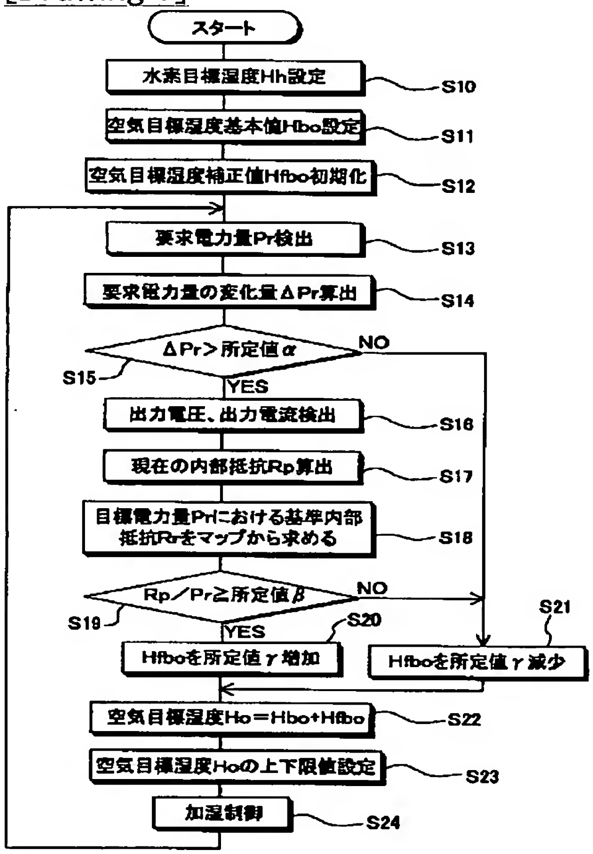

[Drawing 4]



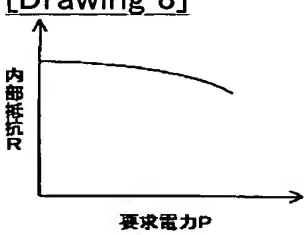
[Drawing 6]



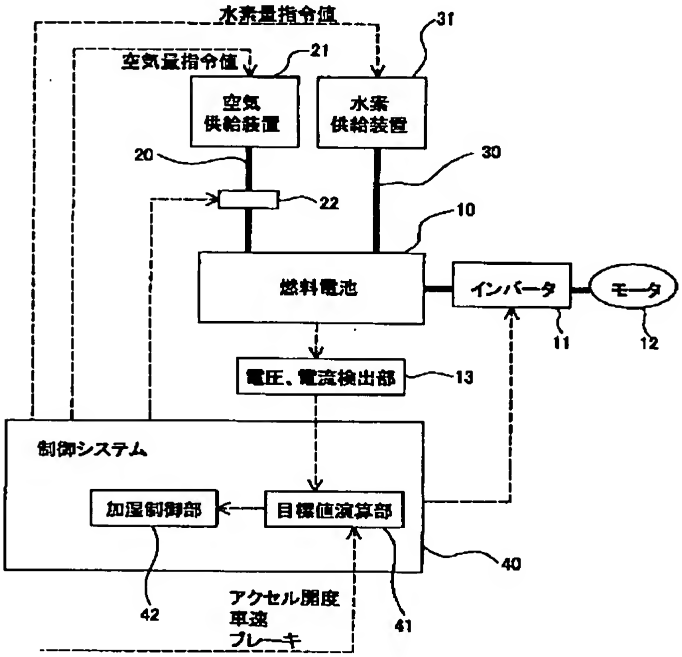

[Drawing 7]



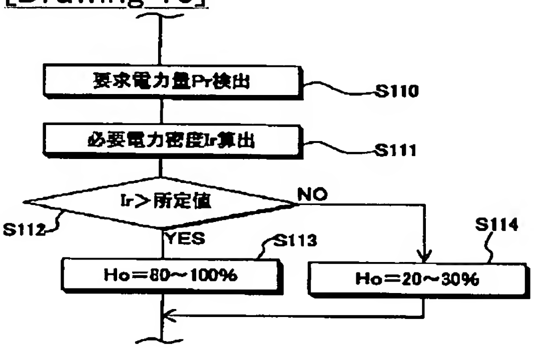

[Drawing 8]



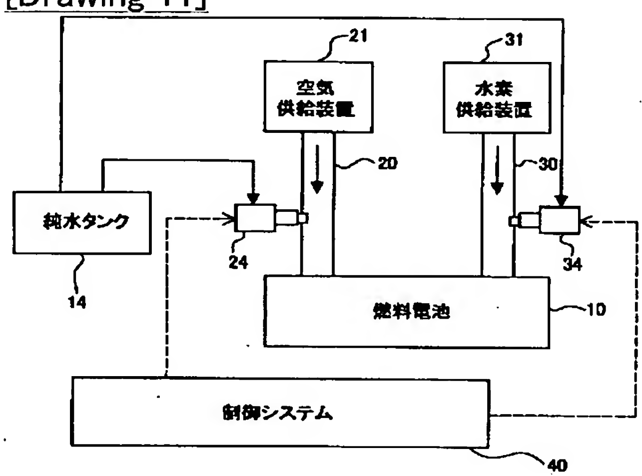

[Drawing 9]



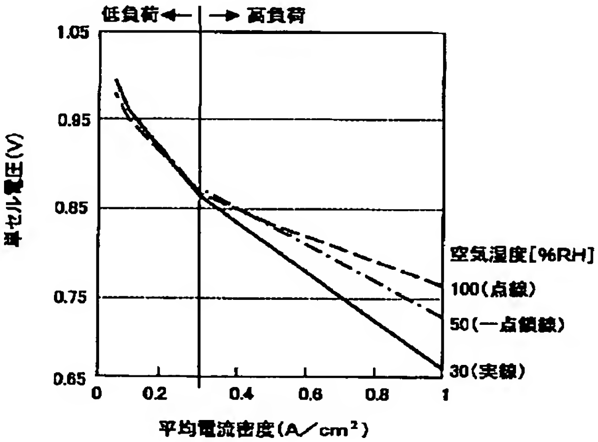

[Drawing 10]




[Drawing 11]




[Drawing 12]

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(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（Ａ）　(11)特許出願公開番号
特開2002−252011
（P2002−252011A）
(43)公開日　平成14年9月6日(2002.9.6)

| (51)Int.Cl.⁷ | 識別記号 | ＦＩ | テーマコード゛(参考) |
|---|---|---|---|
| Ｈ０１Ｍ　8/04 | | Ｈ０１Ｍ　8/04 | Ｋ　５Ｈ０２６ |
| 8/10 | | 8/10 | ５Ｈ０２７ |

審査請求　未請求　請求項の数６　ＯＬ　（全　８　頁）

(21)出願番号　特願2001−48712(P2001−48712)

(22)出願日　平成13年2月23日(2001.2.23)

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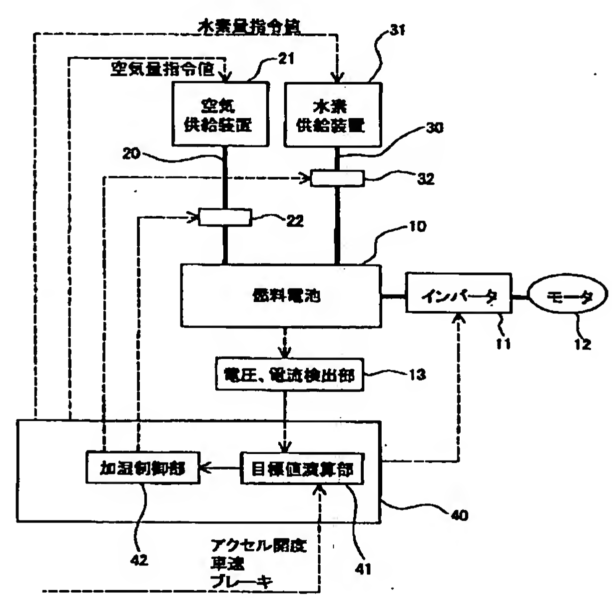
最終頁に続く

(54)【発明の名称】　燃料電池システム

(57)【要約】
【課題】　燃料電池内部の水分状態を最適に保ち、高効率な発電を可能とする燃料電池システムを提供する。
【解決手段】　燃料電池１０に対する要求電力量Ｐｒと、電圧電流検出手段１３にて検出した出力電圧値および出力電流値から求められる燃料電池１０の内部抵抗値Ｒｐとに基づいて、燃料電池１０に供給される酸素の加湿度を制御する。要求電力量Ｐｒにおける燃料電池１０の内部抵抗理論値Ｒｒに対する内部抵抗値Ｒｐの比が所定値を超えている場合には、水分が不足していると推定できるので、燃料電池１０に供給される酸素の加湿度を所定量増加させる。



【特許請求の範囲】
【請求項１】　水素と酸素とを電気化学反応させて電気エネルギを発生させる燃料電池（１０）を備える燃料電池システムであって、
前記燃料電池（１０）に供給される水素および酸素のうち少なくとも酸素を加湿する加湿手段（２２、２４）と、
前記燃料電池（１０）の出力電圧値および出力電流値を検出する電圧電流検出手段（１３）と、
前記燃料電池（１０）に対する要求電力量（Ｐｒ）と、前記電圧電流検出手段（１３）にて検出した前記出力電圧値および前記出力電流値から求められる前記燃料電池（１０）の内部抵抗値（Ｒｐ）とに基づいて、前記燃料電池（１０）に供給される酸素の加湿度を制御する制御部（４０）とを備えることを特徴とする燃料電池システム。
【請求項２】　前記制御部（４０）は、前記燃料電池（１０）に供給される酸素の加湿度が目標加湿度になるように加湿量制御を行うものであり、前記要求電力量（Ｐｒ）における前記燃料電池（１０）の内部抵抗理論値（Ｒｒ）に対する前記内部抵抗値（Ｒｐ）の比が所定値を超えている場合に、前記目標加湿度を所定値増加させることを特徴とする請求項１に記載の燃料電池システム。
【請求項３】　前記制御部（４０）は、前記要求電力量（Ｐｒ）の変化量（ΔＰｒ）が所定変化量を超えている場合に、前記目標加湿度を所定値増加させることを特徴とする請求項２に記載の燃料電池システム。
【請求項４】　前記制御部（４０）は、前記燃料電池（１０）が前記要求電力量（Ｐｒ）を出力するために必要とされる前記燃料電池（１０）の電流密度が所定電流密度を超えている場合には、前記電流密度が所定電流密度を超えていない場合に比較して、前記目標加湿度の初期値を高く設定することを特徴とする請求項１ないし３のいずれか１つに記載の燃料電池システム。
【請求項５】　前記加湿手段はタンク内に貯蔵された水にガスを通過させるバブリング式の加湿装置（２２）であって、前記加湿装置（２２）は前記燃料電池（１０）に供給される酸素が前記加湿装置をバイパスできるバイパス経路（２０ａ）を備えており、
前記制御部（４０）は、前記酸素が前記加湿装置（２２）を通過する時間と前記バイパス経路（２０ａ）を通過する時間との割合を制御して、前記酸素の加湿度を制御することを特徴とする請求項１ないし４のいずれか１つに記載の燃料電池システム。
【請求項６】　前記加湿手段は、前記燃料電池（１０）に供給される酸素に水を噴射するインジェクタ式の加湿装置（２４）であって、
前記制御部（４０）は、前記加湿装置（２４）の水分噴射量を制御して、前記酸素の加湿度を制御することを特徴とする請求項１ないし４のいずれか１つに記載の燃料電池システム。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、水素と酸素との化学反応により電気エネルギーを発生させる燃料電池からなる燃料電池システムに関するもので、車両、船舶及びポータブル発電器等の移動体に適用して有効である。
【０００２】
【従来の技術】例えば電気自動車に搭載される燃料電池システムでは、燃料電池が車両走行に必要な電力を発電するための水素量および酸素量（空気量）を導出し、これらのガスを燃料電池に供給している。
【０００３】発電時における燃料電池の内部抵抗は、燃料電池内部の電解質膜の湿潤度に影響することが知られており、充分な湿潤が得られず電解質膜が乾燥した場合には、内部抵抗が大きくなり燃料電池内における電力損失が増大する。このため、効率のよい電力供給を行うためには、水素および空気を加湿した状態で供給し、燃料電池内部の湿潤を保つ必要がある。
【０００４】
【発明が解決しようとする課題】ところが、現状では燃料電池に供給される水素および空気に対する加湿量の制御は行われていない。このため、経時的に変化する負荷に対して、燃料電池内部の水分が不足あるいは過剰となる場合がある。
【０００５】図１２は燃料電池に対する負荷、セル電圧、平均電流密度、供給される空気の湿度の関係を示しており、負荷が急激に増大した場合に、燃料電池内部の水分量が不足していると燃料電池の出力が低下する。このように、水分が不足した場合には、内部抵抗が増大して燃料電池の出力および発電効率が低下するという問題がある。
【０００６】また、水分が過剰である場合には、燃料電池内部において凝縮した水がガス流路を塞いでしまい、発電のためのガスが充分行き渡らずに燃料電池の出力が低下したり、低温時において凝縮した水が凍結することで発電ができず起動が困難になるという問題がある。
【０００７】本発明は、上記問題点に鑑み、燃料電池内部の水分状態を最適に保ち、高効率な発電を可能とする燃料電池システムを提供することを目的とする。
【０００８】
【課題を解決するための手段】上記目的を達成するため、請求項１に記載の発明では、水素と酸素とを電気化学反応させて電気エネルギを発生させる燃料電池（１０）を備える燃料電池システムであって、燃料電池（１０）に供給される水素および酸素のうち少なくとも酸素を加湿する加湿手段（２２、２４）と、燃料電池（１０）の出力電圧値および出力電流値を検出する電圧電流検出手段（１３）と、燃料電池（１０）に対する要求電

力量（Ｐｒ）と、電圧電流検出手段（１３）にて検出した出力電圧値および出力電流値から求められる燃料電池（１０）の内部抵抗値（Ｒｐ）とに基づいて、燃料電池（１０）に供給される酸素の加湿度を制御する制御部（４０）とを備えることを特徴としている。

【０００９】このように、燃料電池（１０）に対する要求電力量（Ｐｒ）と、燃料電池（１０）の内部抵抗値（Ｒｐ）に基づいて酸素の加湿度を制御することにより、燃料電池（１０）内部の電解質膜の湿潤度を最適状態に保つことができる。なお、本明細書中においては、「酸素」は酸素ガス単独のみならず、酸素ガスを含んでいる空気を含む。

【００１０】また、燃料電池（１０）の内部抵抗値が大きい場合には、燃料電池内の水分が不足していると推定できるため、請求項２に記載の発明では、要求電力量（Ｐｒ）における燃料電池（１０）の内部抵抗理論値（Ｒｒ）に対する内部抵抗値（Ｒｐ）の比が所定値を超えている場合に、目標加湿度を所定値増加させている。

【００１１】また、燃料電池の負荷変動が大きい場合、すなわち、燃料電池に対する要求電力量の変動が大きい場合に燃料電池内の水分が不足することから、請求項３に記載の発明では、要求電力量（Ｐｒ）の変化量（ΔＰｒ）が所定変化量を超えている場合に、酸素の目標加湿度を所定値増加させている。

【００１２】また、請求項４に記載の発明では、制御部（４０）は、燃料電池（１０）が要求電力量（Ｐｒ）を出力するために必要とされる燃料電池（１０）の電流密度が所定電流密度を超えている場合には、電流密度が所定電流密度を超えていない場合に比較して、目標加湿度の初期値を高く設定することを特徴としている。

【００１３】このように、空気目標加湿度の初期値を、低負荷時には低く設定し、高負荷時には高く設定することで、空気目標加湿度をより速く適切な値にすることができる。なお、燃料電池（１０）の電流密度に代えて、燃料電池に対する要求電力量に基づいて目標加湿度の初期値を設定してもよい。

【００１４】また、加湿手段は、請求項５に記載の発明のように、タンク内に貯蔵された水にガスを通過させるバブリング式の加湿装置（２２）を用いることができ、あるいは、請求項６に記載の発明のように、燃料電池（１０）に供給される酸素に水を噴射するインジェクタ式の加湿装置（２４）を用いることができる。

【００１５】なお、上記各手段の括弧内の符号は、後述する実施形態に記載の具体的手段との対応関係を示すものである。

【００１６】

【発明の実施の形態】（第１実施形態）以下、本発明の第１実施形態を図１～図８に基づいて説明する。本第１実施形態は、燃料電池システムを燃料電池を電源として走行する電気自動車（燃料電池車両）に適用したものである。

【００１７】図１は、実施形態の燃料電池システムの全体構成を示している。図１に示すように、本実施形態の燃料電池システムは、水素と酸素との電気化学反応を利用して電力を発生する燃料電池（ＦＣスタック）１０を備えている。本第１実施形態ではＦＣスタック１０として固体高分子電解質型燃料電池を用いており、基本単位となるセルが複数積層されて構成されている。各セルは、電解質膜が一対の電極で挟まれた構成となっている。

【００１８】ＦＣスタック１０では、以下の水素と酸素の電気化学反応が起こり電気エネルギが発生する。

（負極側）$H_2 \rightarrow 2H^+ + 2e^-$

（正極側）$2H^+ + 1/2O_2 + 2e^- \rightarrow H_2O$

ＦＣスタック１０は、インバータ１１や図示しない２次電池等の電気機器に電力を供給するように構成されている。インバータ１１は、ＦＣスタック１０から供給された直流電流を交流電流に変換して走行用モータ（負荷）１２に供給し、モータ１２を駆動している。図２は燃料電池システムにおけるＦＣスタック１０の電圧電流検出部の拡大図であり、図２に示すようにＦＣスタック１０には、ＦＣスタック１０の出力電圧値および出力電流値を検出する電圧電流検出部１３が設けられている。

【００１９】図３は、燃料電池システムにおけるガス供給部の拡大図である。図３に示すように、燃料電池システムには、ＦＣスタック１０の酸素極（正極）側に空気（酸素）を供給するための空気経路２０と、ＦＣスタック１０の水素極（負極）側に水素を供給するための水素経路３０が設けられている。空気経路２０には空気供給装置２１が設けられ、水素経路３０には水素供給装置３１が設けられている。空気供給装置２１としては、例えば空気圧送用の送風機（ガス圧縮機）を用いることができ、水素供給装置３１としては、例えば水蒸気改質装置を用いることができる。

【００２０】発電時における電気化学反応のために、ＦＣスタック１０内の電解質膜を水分を含んだ湿潤状態にしておく必要がある。このため、空気経路２０には空気に加湿を行うための加湿装置２２が設けられている。同様に、水素経路３０には水素に加湿を行うための加湿装置３２が設けられている。図３に示すように、本第１実施形態では、加湿装置２２、３２には、タンク内の水にガスを通過させて加湿するバブリング方式の加湿装置を用いている。

【００２１】これらの加湿装置２２、３２により、空気経路２０を通過する空気および水素経路３０を通過する水素に加湿が行われ、ＦＣスタック１０には加湿された空気および水素が供給される。これにより、ＦＣスタック１０内部は湿潤状態で作動することとなる。

【００２２】本第１実施形態の燃料電池システムでは、図３に示すように、空気経路２０および水素経路３０に

は、それぞれ加湿装置２２、３２のバイパス経路２０ａ、３０ａが設けられている。それぞれのガス経路２０、３０とバイパス経路２０ａ、３０ａとの分岐点には、流路切替弁２３、３３が設けられている。流路切替弁２３、３３は、バルブオンでガスを加湿装置２１、３１側に流し、バルブオフでガスをバイパス通路２０ａ、３０ａ側に流すように構成されている。

【００２３】ここで、加湿装置２２、３２による空気あるいは水素への加湿量制御について説明する。ＦＣスタック１０に供給されるガスの加湿量制御は、流路切替弁２３、３３をデューティ比制御し、ガスが加湿装置２２、３２とバイパス通路２０ａ、３０ａとを通過する時間割合を制御することで行う。

【００２４】図４は加湿装置２２、３２の制御説明図である。図４（ａ）は目標加湿度Ｈｒ（％ＲＨ：相対湿度）とバルブオンデューティＤｔ（％）との関係を予め設定したマップであり、図４（ｂ）はバルブ動作周期Ｔｐ（秒）とバルブオン時間Ｔｏｎ（秒）との関係を示している。バルブオンデューティＤｔは、バルブ動作周期Ｔｐにおけるバルブオン時間Ｔｏｎの割合である。図４（ａ）のマップは加湿装置２２、３２の種類等に従って適宜設定されるものである。バルブ動作周期Ｔｐは任意に設定でき、本実施形態ではＴｐ＝５秒としている。

【００２５】図４（ａ）のマップから目標加湿度に基づいてバルブオンデューティＤｔを求め、バルブ動作周期Ｔｐに対するバルブオン時間ＴｏｎをＴｏｎ＝Ｔｐ×Ｄｔ／１００（秒）で求める。

【００２６】図５はＦＣスタック１０内部における水分の移動状態を示している。図５に示すように、ＦＣスタック１０内部では、空気極１０ｃ側の水分が電解質膜１０ｂ中を空気極１０ｃ側から水素極１０ａ側に拡散する。この水分拡散により、電解質膜１０ｂの伝導率がある程度大きく保たれることとなる。

【００２７】図６は、空気湿度が１００％ＲＨの場合における、水素湿度（％ＲＨ）、電流密度（Ａ／ｃｍ$^2$）、単セル電圧（Ｖ）の関係を示している。図６より、電流密度とセル電圧の関係は、水素湿度の変化にほとんど影響を受けないことが分かる。

【００２８】従って、本第１実施形態の燃料電池システムでは、水素の加湿量を極力低減し、主に空気の加湿量を制御することで、ＦＣスタック１０内部の湿度制御を行っている。

【００２９】本実施形態の燃料電池システムには各種制御を行う制御部（ＥＣＵ）４０が設けられている。制御部４０には、ガスの目標加湿度を演算する目標値演算部４１と、目標加湿度に基づいてガス加湿量を制御する加湿量制御部４２を備えている。制御部４０には、負荷１１からの要求電力信号、電圧電流検出部１３からの電圧値および電流値等が入力される。また、制御部５０は、インバータ１１、ガス供給装置２１、３１、流路切替弁２３、３３等に制御信号を出力するように構成されている。

【００３０】次に、上記構成の燃料電池システムの作動を図７に基づいて説明する。図７は本実施形態の燃料電池システムの作動を示すフローチャートである。なお、制御周期は数ミリ秒～数十ミリ秒とする。

【００３１】まず、水素の目標湿度Ｈｈを設定し（ステップＳ１０）、空気の目標湿度基本値Ｈｂｏを設定する（ステップＳ１１）。水素目標湿度Ｈｈを例えば２０％ＲＨに設定し、空気目標湿度基本値Ｈｂｏを例えば３０％ＲＨに設定する。空気目標湿度補正値Ｈｆｂｏの初期値を０に設定する（ステップＳ１２）。

【００３２】次に、アクセル開度、車速、ブレーキ等の信号に基づいて、車両走行に必要とされる要求電力Ｐｒを検出する（ステップＳ１３）。現在の要求電力Ｐｒ（ｔ）と前回制御時の要求電力Ｐｒ（ｔ－１）との差ΔＰｒを算出し（ステップＳ１４）、要求電力の変化量ΔＰｒが所定値α（例えば５ｋＷ）を超えているか否かを判定する（ステップＳ１５）。すなわち、ＦＣスタック１０に対する負荷変動が急激な増大であるか否かを判定する。

【００３３】この結果、要求電力の変化量ΔＰｒが所定値αを超えている場合には、まず、電圧電流検出部１３によりＦＣスタック１０の現在の出力電圧値Ｖｐおよび出力電流値Ｉｐを検出し（ステップＳ１６）、ＦＣスタック１０の現在の内部抵抗値Ｒｐを、Ｒｐ＝Ｖｐ／Ｉｐで算出する（ステップＳ１７）。

【００３４】次に、上記ステップＳ１３で検出した要求電力ＰｒにおけるＦＣスタック１０の内部抵抗基準値Ｒｒを求める（ステップＳ１８）。図８は、要求電力ＰｒとＦＣスタック１０の内部抵抗値Ｒｒとの関係を予め設定したマップである。図８に示すマップから、ＦＣスタック１０が要求電力Ｐｒを出力した場合の内部抵抗基準値Ｒｒを求める。

【００３５】次に、現在の内部抵抗値Ｒｐの要求電力Ｐｒにおける内部抵抗基準値Ｒｒに対する比が所定値β（例えば１１０％）を超えているか否か、Ｒｐ／Ｒｒ≧βであるか否かを判定する（ステップＳ１９）。すなわち、要求電力量Ｐｒに対する内部抵抗理論値である内部抵抗基準値Ｒｒに対して、実際の内部抵抗値Ｒｐが大きすぎないか否かを判定する。

【００３６】この結果、内部抵抗基準値Ｒｒに対して実際の内部抵抗値Ｒｐが所定値以上大きい場合には、ＦＣスタック１０内の水分量が不足していると推定されるので、空気目標湿度補正値Ｈｆｂｏを所定値γ（例えば１％ＲＨ）だけ増加させる（ステップＳ２０）。

【００３７】一方、内部抵抗基準値Ｒｒに対して現在の内部抵抗値Ｒｐが所定値より小さい場合には、ＦＣスタック１０内の水分量は不足していないと推定されるので、空気目標湿度補正値Ｈｆｂｏを所定値γだけ減少さ

せる（ステップＳ２１）。また、上記ステップＳ１５で要求電力の変化量ΔＰｒが所定値αを超えていない場合にも、同様に空気目標湿度補正値Ｈｆｂｏを所定値γだけ減少させる。これにより、ステップＳ２０で増加させる空気加湿量が無限に増大するのを防止することができる。

【００３８】次に、最終的な空気目標湿度Ｈｏを、空気目標湿度基本値Ｈｂｏと空気目標湿度補正値Ｈｆｂｏとの和から求める（ステップＳ２２）。この空気目標湿度Ｈｏに上下限値を設定する（ステップＳ２３）。すなわち、空気目標湿度Ｈｏが０％ＲＨより小さい場合には０％ＲＨに設定し、１００％ＲＨより大きい場合には１００％ＲＨに設定する。

【００３９】次に、空気目標湿度Ｈｏおよび水素目標湿度Ｈｈに基づいて、加湿装置２２、３２により空気あるいは水素の加湿制御を行う（ステップＳ２４）。加湿制御は、上述したように、流路切替弁２３、３３を用いたデューティ比制御により、ＦＣスタック１０に供給される空気および水素の加湿度が、空気目標湿度Ｈｏおよび水素目標湿度Ｈｈとなるように行われる。以下、上記ステップＳ１３～Ｓ２４の制御ループを繰り返し行う。

【００４０】以上のように、負荷の状態に応じて内部抵抗値を推定し、この内部抵抗値に基づいてガスの加湿量を制御することで、ＦＣスタック１０内部の水分状態を常に最適にすることが可能となる。これにより高効率な発電が可能となる。また、燃料電池内部の水分量を少なくできるので、低温時における燃料電池の起動性も向上させることができる。

【００４１】なお、水素目標湿度Ｈｈ、空気目標湿度基本値Ｈｂｏおよび所定値α、β、γは、燃料電池の種類等に応じて任意に設定できる値である。

【００４２】（第２実施形態）次に、本発明の第２実施形態を図９に基づいて説明する。本第２実施形態は、上記第１実施形態に比較して、水素経路３０に設けられていた加湿装置３２を省略した点が異なるものである。上記第１実施形態と同様の部分は、同一の符号を付して説明を省略する。

【００４３】図９は、本第２実施形態の燃料電池システムの全体構成を示している。上記第１実施形態で図５、図６に基づいて説明したように、燃料電池の出力は供給水素の湿度にほとんど影響を受けない。このため、図９に示すように本第２実施形態の燃料電池システムでは、水素経路３０には加湿装置を設けず、空気経路２０にのみ加湿装置２２を設け、供給空気の加湿量を制御することでＦＣスタック１０内部の湿度制御を行っている。

【００４４】このような構成によっても、ＦＣスタック１０内部では空気極側の水分が電解質膜中を水素極側に拡散するため、電解質膜の伝導率がある程度大きく保たれる。従って、本第２実施形態の構成によっても、上記第１実施形態の燃料電池システムと同様の効果を得ることができる。また、本第２実施形態の構成によれば、システムの簡略化を図ることができる。

【００４５】（第３実施形態）次に、本発明の第３実施形態を図１０に基づいて説明する。本第３実施形態は、上記第１実施形態に比較して、空気目標湿度基本値Ｈｂｏの設定方法が異なるものである。上記第１実施形態と同様の部分は、同一の符号を付して説明を省略する。

【００４６】図１０は空気目標湿度基本値Ｈｂｏの設定手順を示すフローチャートであり、上記第１実施形態で説明した図７のステップＳ１１に対応している。以下、図１０に基づいて、本第３実施形態における空気目標湿度基本値Ｈｂｏの設定方法を説明する。

【００４７】まず、アクセル開度、アクセル開度、車速、ブレーキ等の信号に基づいて、車両走行に必要とされる要求電力量Ｐｒを検出する（ステップＳ１１０）。次に、ＦＣスタック１０が要求電力量Ｐｒを出力するために必要な電流密度Ｉｒを算出する（ステップＳ１１１）。要求電力量Ｐｒに対する必要電流密度Ｉｒは、インバータ１１の種類によって一義的に定まる。

【００４８】次に、必要電流密度Ｉｒが所定電流密度を超えているか否か、すなわちＦＣスタック１０に対する負荷が高負荷であるか低負荷であるかを判定する（ステップＳ１１２）。高負荷であるか低負荷であるかの基準値である所定電流密度は、燃料電池の種類等に応じて任意に設定できる値であり、例えば図１２に示すように０．３Ａ／$cm^2$と設定することができる。

【００４９】この結果、必要電流密度Ｉｒが所定値を超えている場合には、空気目標湿度基本値Ｈｂｏを例えば８０～１００％ＲＨに設定する（ステップＳ１１３）。一方、必要電流密度Ｉｒが所定値を超えていない場合には、空気目標湿度基本値Ｈｂｏを例えば２０～３０％ＲＨに設定する（ステップＳ１１４）。これらの値も、燃料電池の種類等に応じて任意に設定できる値である。

【００５０】このように、空気目標湿度Ｈｏの初期値を、低負荷時には低く設定し、高負荷時には高く設定することで、空気目標加湿度Ｈｏをより速く適切な値にすることができる。

【００５１】（第４実施形態）次に、本発明の第４実施形態を図１１に基づいて説明する。本第４実施形態は、上記第１実施形態に比較して、加湿装置２２、３２の構成が異なるものである。上記第１実施形態と同様の部分は、同一の符号を付して説明を省略する。

【００５２】図１１は、本第４実施形態の燃料電池システムの概略図である。上記第１実施形態と同様の部分は適宜図示を省略している。

【００５３】図１１に示すように本第４実施形態では、インジェクタ式のガス加湿装置２４、３４が設けられている。インジェクタ式加湿装置２４、３４は、純粋タンク１４から純水が供給され、制御部４０からの制御信号に基づいてガス通路２０、３０内に水を噴射し、ガスに

加湿するように構成されている。インジェクタ式加湿装置２４、３４では、空気目標湿度Ｈｏおよび水素目標湿度Ｈｈに基づいて水分噴射量が制御される。

【００５４】このようなインジェクタ式加湿装置２４、３４を用いることで、より応答性がよく、かつ高精度な加湿制御を行うことが可能となる。

【００５５】（他の実施形態）なお、上記第１～第３実施形態では、バブリング式加湿装置２２、３２にバイパス通路２０ａ、３０ａを設けてデューティ比制御することで加湿度制御を行ったが、これに限らず、例えば加湿されたガスの温度を調整することによっても湿度制御を行うことができる。具体的には、ガス温度を上げることによって湿度を低くすることができ、ガス温度を下げることによって湿度を高くすることができる。

【図面の簡単な説明】

【図１】上記第１実施形態の燃料電池システムの概念図である。

【図２】図１の燃料電池の拡大概念図である。

【図３】図１の加湿装置の拡大概念図である。

【図４】加湿器の加湿制御を示す特性図である。

【図５】燃料電池内部における水分の移動状態を示す概念図である。

【図６】水素湿度、空気湿度、セル電圧、電流密度の関係を示す特性図である。

【図７】上記第１実施形態の燃料電池システムの加湿制御を示すフローチャートである。

【図８】要求電力と内部抵抗との関係を示す特性図である。

【図９】上記第２実施形態の燃料電池システムの概念図である。

【図１０】上記第３実施形態の燃料電池システムのフローチャートである。

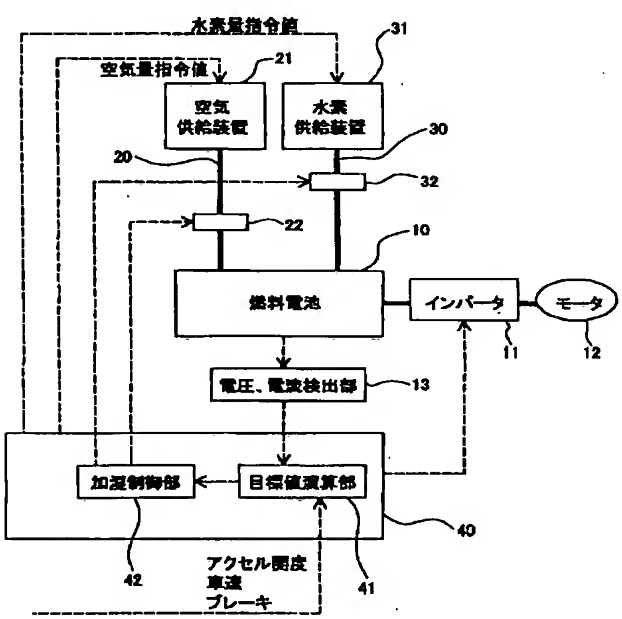
【図１１】上記第４実施形態の燃料電池システムの概念図である。

【図１２】燃料電池に対する負荷、セル電圧、平均電流密度、供給される空気の湿度の関係を示す特性図である。

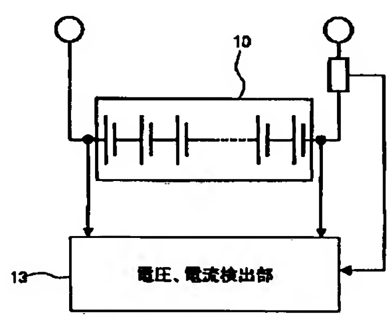
【符号の説明】

１０…燃料電池（ＦＣスタック）、１３…電圧電流検出部、２０、３０…ガス経路、２１、３１…ガス供給装置、２２、３２…加湿装置、４０…制御部。

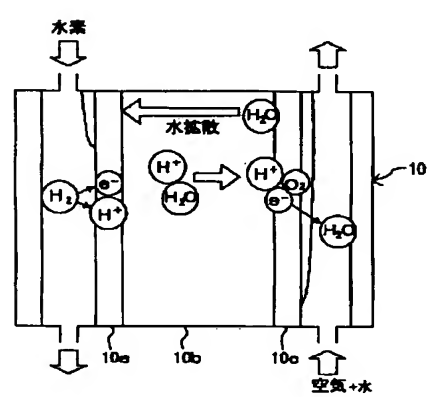
【図１】



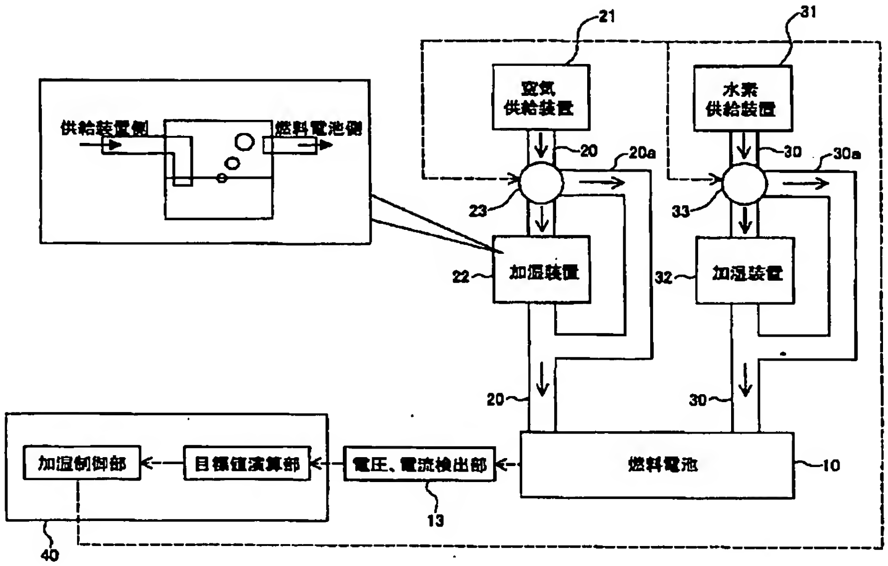

【図２】




【図５】

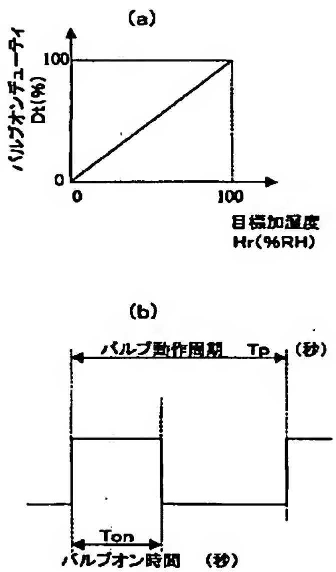


【図３】



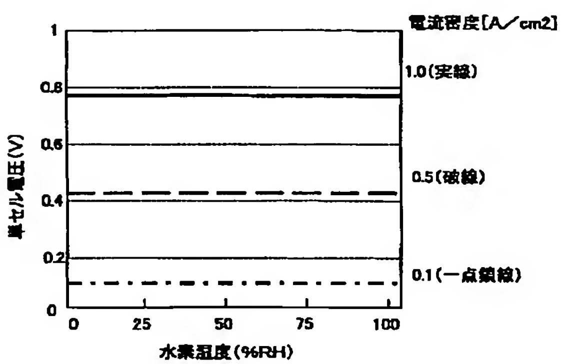
21
31
空気供給装置
水素供給装置
供給装置側
燃料電池側
20
20a
30
30a
23
33
22
加湿装置
32
加湿装置
20
30
加湿制御部
目標値演算部
電圧、電流検出部
燃料電池
10
13
40


【図４】



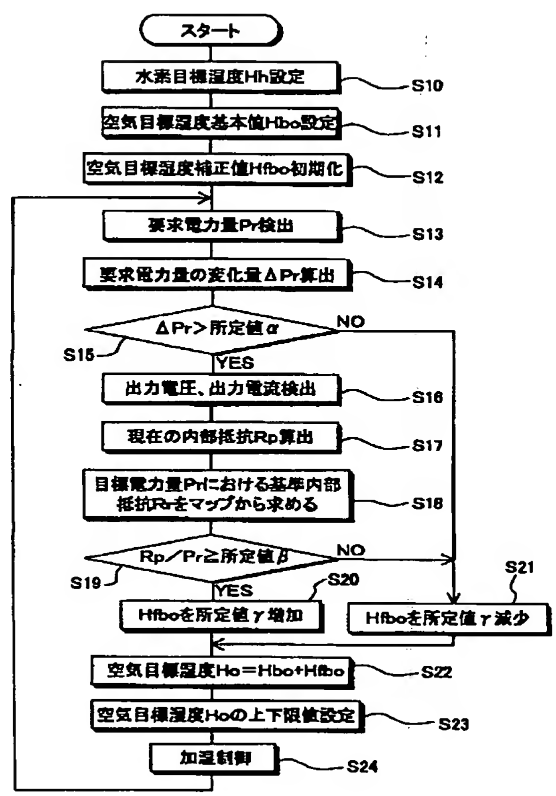
(a)
バルブオンデューティ Dt(%)
100
0
0
100
目標加湿度 Hr(%RH)
(b)
バルブ動作周期 Tp (秒)
Ton
バルブオン時間 (秒)


【図６】



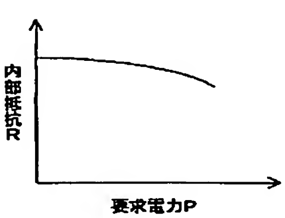
電流密度[A／cm2]
1.0(実線)
0.5(破線)
0.1(一点鎖線)
単セル電圧(V)
1
0.8
0.6
0.4
0.2
0
0
25
50
75
100
水素湿度(%RH)


【図７】



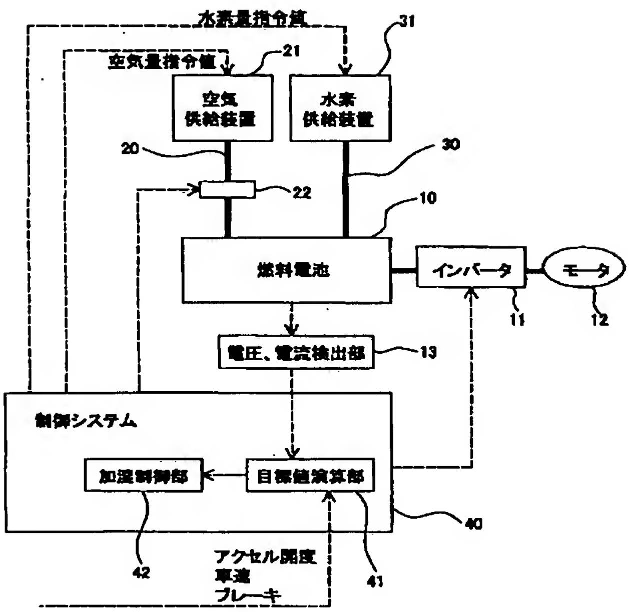
スタート
水素目標湿度Hh設定
S10
空気目標湿度基本値Hbo設定
S11
空気目標湿度補正値Hfbo初期化
S12
要求電力量Pr検出
S13
要求電力量の変化量ΔPr算出
S14
ΔPr＞所定値α
NO
S15
YES
出力電圧、出力電流検出
S16
現在の内部抵抗Rp算出
S17
目標電力量Prにおける基準内部抵抗Rrをマップから求める
S18
Rp／Pr≧所定値β
NO
S19
YES
S20
S21
Hfboを所定値γ増加
Hfboを所定値γ減少
空気目標湿度Ho＝Hbo+Hfbo
S22
空気目標湿度Hoの上下限値設定
S23
加湿制御
S24


【図８】

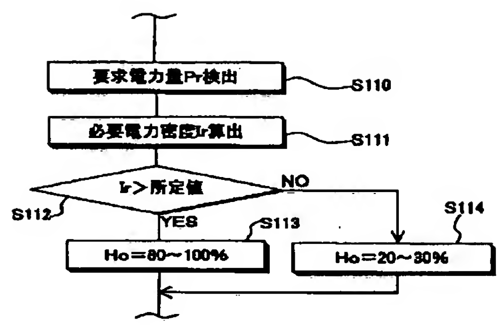


内部抵抗
要求電力P

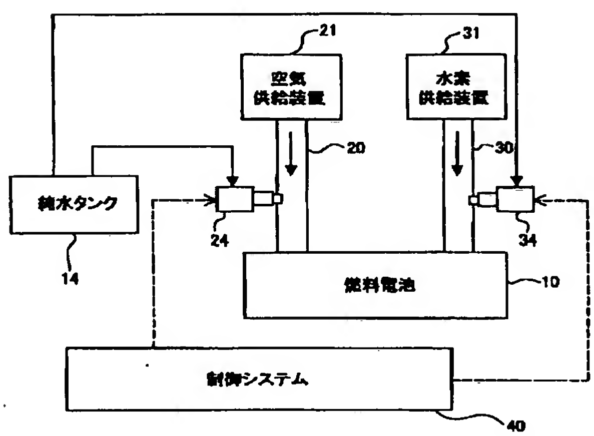
【図９】



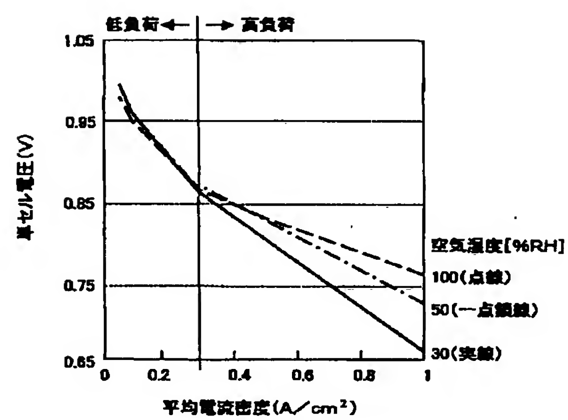

【図１０】




【図１１】




【図１２】

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Ｆターム(参考)　5H026 AA06
5H027 AA06 BA01 DD03 KK54 KK56
MM01 MM04 MM09